# Using an Ensemble of Convection-Allowing Models to Populate PoP and QPF Grids in GFE

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## 1. Introduction

Forecasting convection in the near term is challenging because both convection-allowing and parameterized-convection models struggle to pinpoint where and when convection will occur. The suite of parameterized models and MOS guidance sources currently used to generate the near-term forecast often underestimate convective coverage. On the other hand, convection-allowing model Probability of Precipitation (PoP[1]) grids often exhibit extremely high values that are usually displaced slightly in time and space from the observed convection. The camPoP ("convection-allowing model PoP") smart tool was developed to aid forecasters in determining where and when convection will occur in the near term by using a consensus approach. The tool generates PoP grids showing the percentage of convection-allowing models with non-zero Quantitative Precipitation Forecasts (QPF) in any particular grid box at any particular time. The camQPF ("convection-allowing model QPF") tool creates the associated QPF grids generated by averaging the convection-allowing model QPF fields.

## 2. Development and Application

Five convection-allowing models (CAMs) are stored in AWIPS at WFO Greenville Spartanburg (GSP):

- High Resolution Rapid Refresh (HRRR)
- Local Workstation WRF with ARW core (wrfarw)
- Local Workstation WRF with NMM (wrfnnm)
- NCEP High-Resolution WRF-ARW (HIRESWarw)
- NCEP High-Resolution WRF-NMMB (HIRESWnmm)

Other WFOs may have a different set of CAMs.

[1] Probability of Precipitation (PoP), as used here, is a relative frequency of occurrence in the models being examined. This is one method that can be used to populate floating PoP grids in the manner defined in National Weather Service Instruction 10-201 for use in the National Digital Forecast Database (NDFD).

**Table 1. Configuration of Convection-Allowing models available in GFE at WFO GSP.**

| CAM | Grid Spacing | Vertical Levels | Run Frequencies | Forecast Length |
|---|---|---|---|---|
| HRRR[2] | 3km | 50 | 1 hourly | 12 (15) hrs |
| HIRESWarw | 4.2km | 40 | 12 hourly | 48 hrs |
| HIRESWnmmb | 3.6km | 40 | 12 hourly | 48 hrs |
| wrfarw | 4km | 45 | 7 hourly | 24 hrs |
| wrfnmm | 4km | 45 | 6 hourly | 15 hrs |

These models produce explicit forecasts of simulated reflectivity and QPF at time projections ranging up to 12 to 48 hours as shown in Table 1. The challenge using this output operationally is that CAM precipitation guidance, even when performing relatively well, is often displaced slightly in time and space from the observed convection. The Storm Prediction Center (SPC) recently addressed this limitation with the development of the *Storm-Scale Ensemble of Opportunity (SSEO)* guidance (Jirak et al. 2012; http://www.spc.noaa.gov/exper/sseo/). The camPoP procedure produces similar forecast guidance using both local and national CAM guidance, but further extends the utility by creating guidance that can easily be populated or blended into forecast grids in GFE.

A new **CAMPoP_QPF Weather Element Group** was created in GFE (Fig. 1). This group includes four new camPoP guidance grids that cover 1, 3, 6, and 12-hour time periods along with a 3-hourly camQPF grid. These camPoP grids show the percentage of the seven CAMs, including two time-lagged HRRR runs, that produce measurable precipitation within a grid box over the indicated time period. For example, the grid displayed in Fig. 1 shows the camPoP 3-hourly grids (camPoP3) from 0600 to 0900 UTC on 29 April 2014. It displays a rather large area of 100% PoPs stretched along the spine of the Appalachians. This denotes areas where all seven CAMs had measurable precipitation at some point during this 3-hour window (The areas of 14% indicate only 1 out of 7 models with measurable precipitation, etc.). In instances where the latest model run cannot be found, the method uses the previous model run. The camPoP grids are created hourly by a cron at HH+25 which executes procedures that run the camPoP and camQPF smart tools.

[2] WFO GSP Stores 12 of the 15 hours of the experimental HRRR. The HRRR is scheduled to become operational in October 2014.

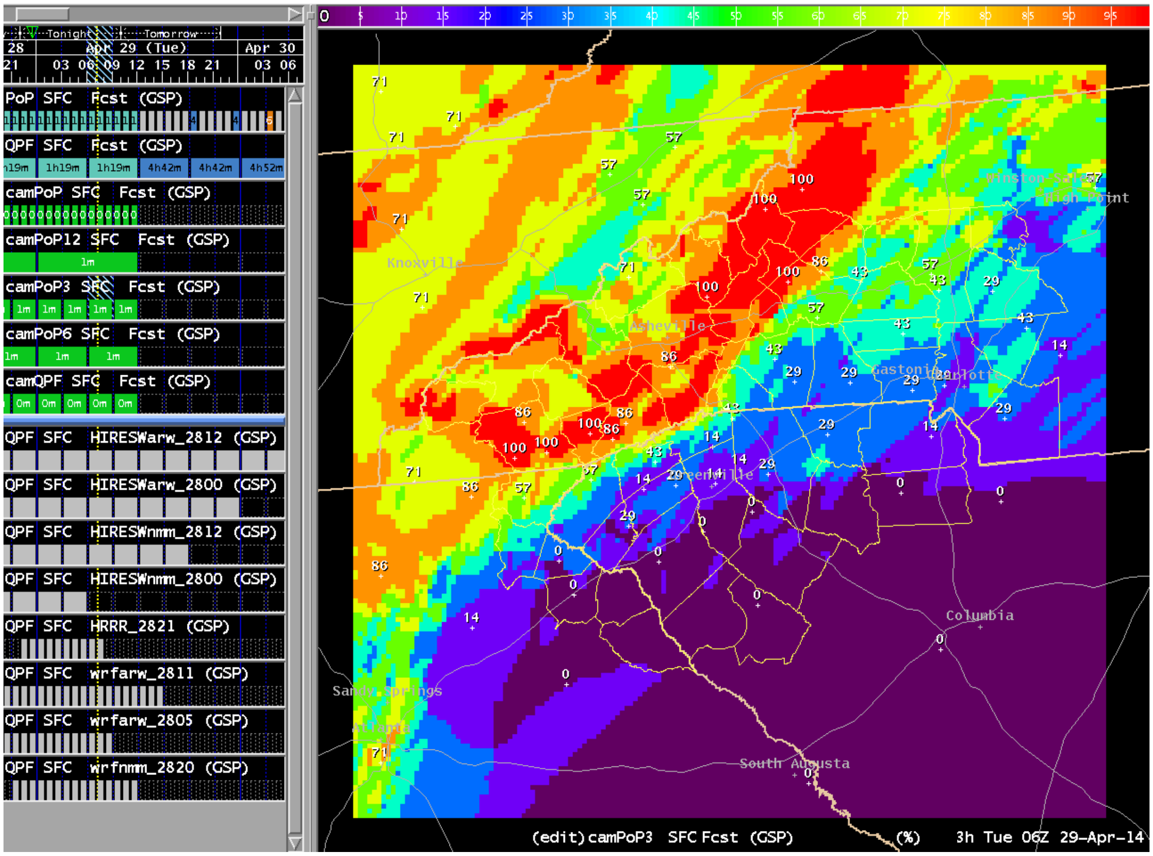


**Fig. 1. camPoP3 grid from 0600-0900 UTC 29 April 2014 as displayed in the CAMPoP_QPF Weather Element Group in GFE. (Based on CAMs available at 2300 UTC 28 April 2014.)**

The camPoP guidance can be populated or blended into forecast PoP grids using the **PoPfmCAMPoP** smart tool (Fig. 2). This adjusts the PoP grid toward higher values in regions of higher camPoP and lower values in regions of lower camPoP. Users simply make editable the PoP grid(s) of choice, select the desired camPoP source, and then run the tool. A "Percent of Fcst PoP to Blend:" slider bar permits blending of the camPoP guidance with the existing forecast PoP grid. Thus, the camPoP source can be populated directly by adjusting the slider bar to 0%. Doing so permits camPoP to be used as a forecast database ("Fcst") model blend source with the traditional "ModelBlend" tool if blending with other guidance sources is desired.

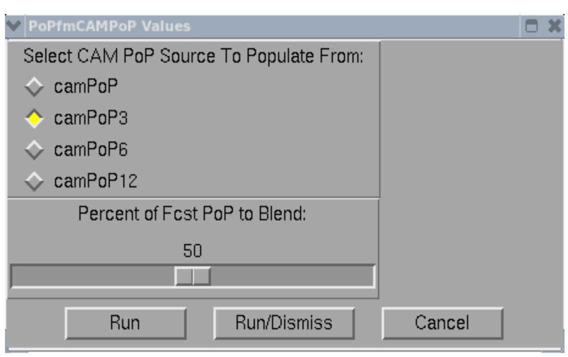


**Fig. 2. PoPfmCAMPoP Smart Tool User Interface.**

The camQPF grid (Fig. 3) is an average of QPF fields from the aforementioned convection-allowing models and serves as a companion to camPoP. This grid can assist forecasters in determining the magnitude of the precipitation.

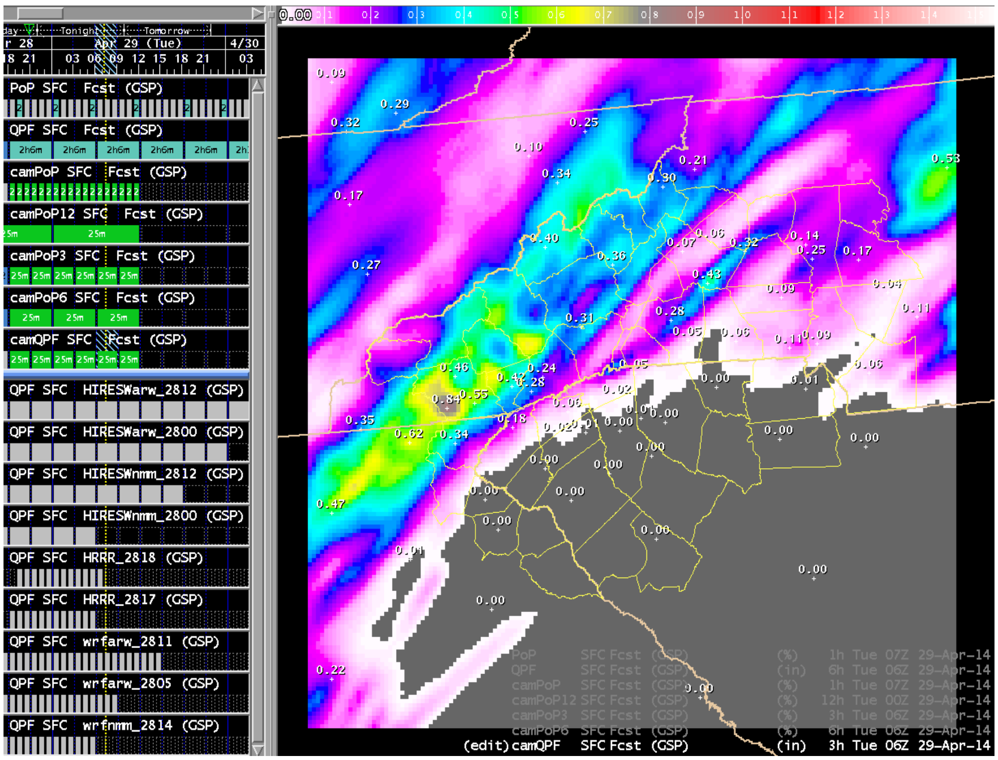


**Fig. 3. 0600-0900 UTC camQPF grid from 29 April 2014 as displayed in the CAMPoP_QPF Weather Element Group in GFE. (Based on CAMs available at 2100 UTC 28 April 2014.)**

The camQPF guidance can be populated or blended into forecast QPF grids using the **QPFfmCAM_QPF** smart tool (Fig. 4). A "Percent of Fcst QPF to Blend with camQPF:" slider bar permits blending of the camQPF guidance with the existing forecast QPF grid. Thus, the camQPF source can be populated directly by adjusting the slider bar to 0%.

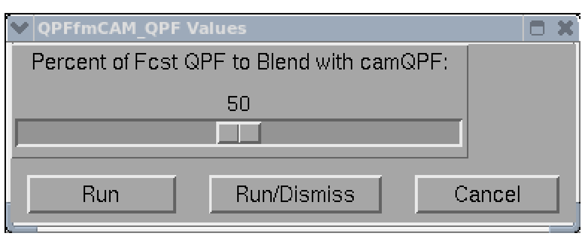


**Fig. 4. QPFfmCAM_QPF Smart Tool User Interface.**

## 3. Limitation

Because the HRRR is available only out to 12 hours from the current time, camPoP has significantly fewer guidance sources to use as input beyond hour 12. For example, Fig. 5 shows

1500 UTC to 1800 UTC PoP grids which were beyond the 12-hour period of HRRR availability from 00 UTC. In this case, the three HRRR runs, wrfarw, and the wrfnmm have been dropped from consideration. Individual models are only used in the calculation if they are available for the whole time period of concern. Hence, the performance of camPoP is typically best within the first 12 hours of the forecast when most or all of the seven possible CAMs are available. There may be some utility of camPoP beyond 12 hours, but the guidance should be used with caution - perhaps with a lower weighted blend.

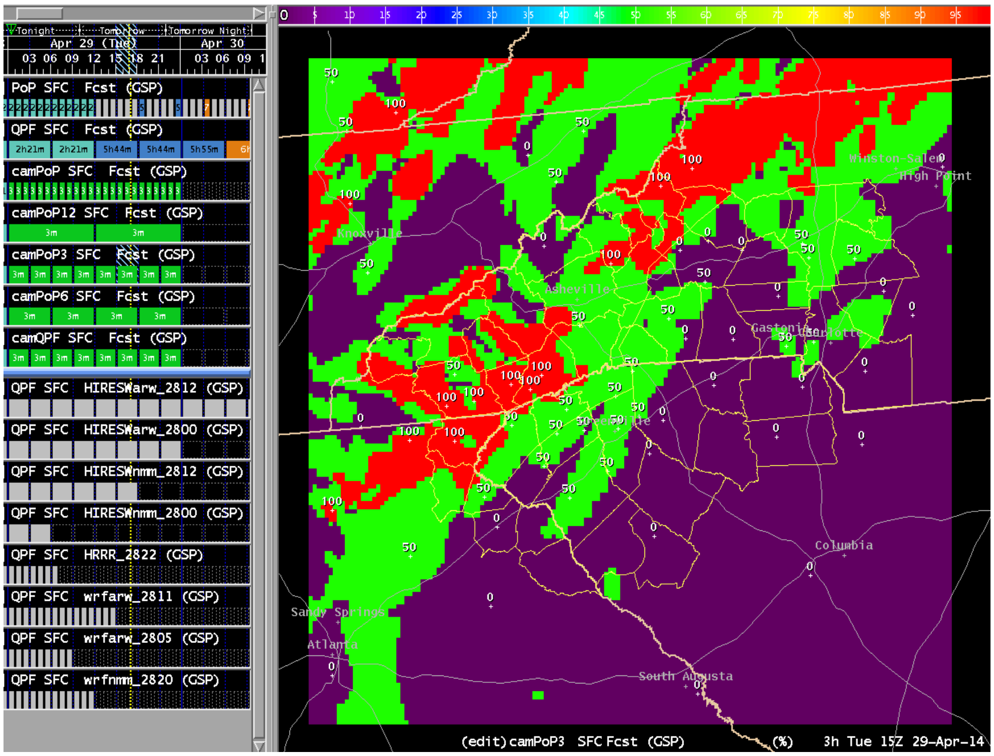

**Fig. 5. 1500-1800 UTC camPoP3 grids from 29 April 2014 as displayed in the CAMPoP_QPF Weather Element Group in GFE. (Based on CAMs available at 00Z 29 April 2014.)**

## 4. Experimental Results

### *a) Warm season examples*

The camPoP guidance frequently proved useful during warm-season convection in 2013. One such example where the guidance was useful occurred on the afternoon of 11 September 2013. Figure 6 depicts the observed dual-polarization radar storm totals from that afternoon. The convective precipitation was mostly confined to the Blue Ridge area of the southern Appalachians where the PoP grids generated by camPoP (Fig. 7) showed 100% in the red shaded area. Such resolution in the PoP guidance is quite rare among models with parameterized convection.

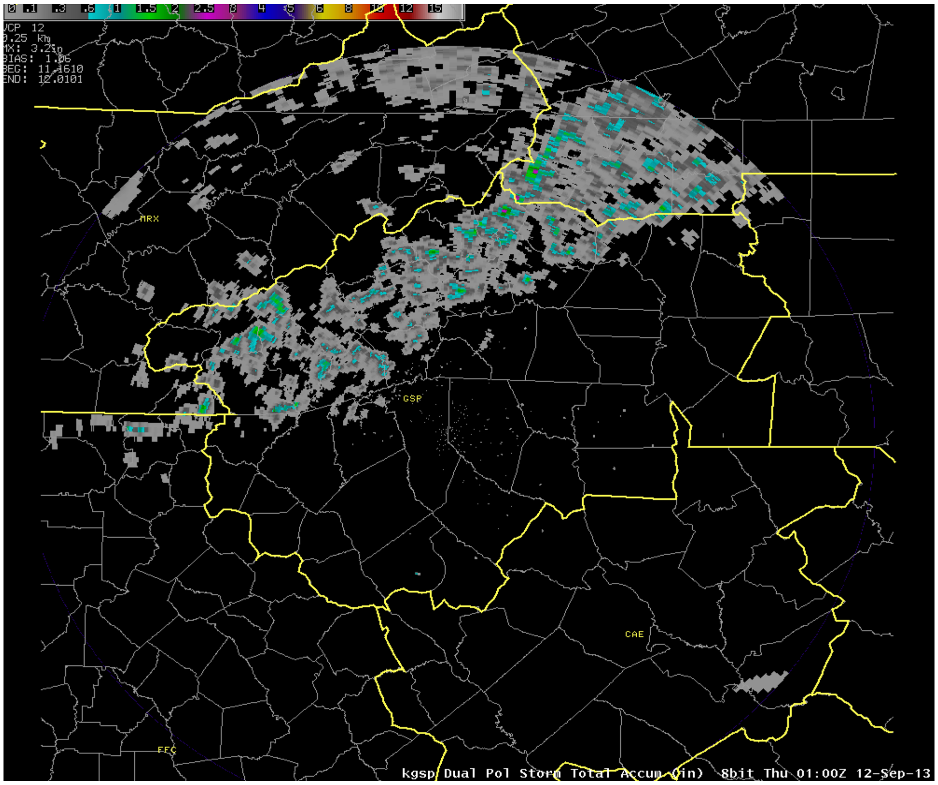


**Fig. 6. Dual Pol Storm Total Precipitation Accumulation starting at 1610 UTC 11 September 2013 and ending at 0100 UTC 11 September 2013.**

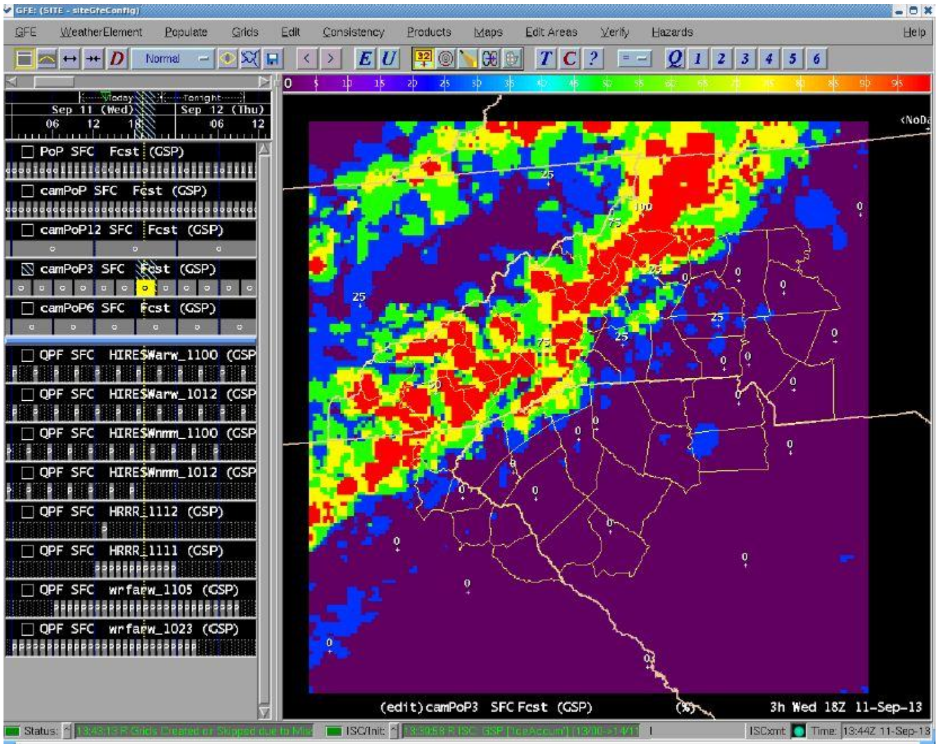


**Fig. 7. camPoP3 grid valid from 1800 to 2100 UTC 11 September 2013 based on CAMs available at 1300 UTC.**

Figure 8 depicts the dual-pol radar observed storm total precipitation during the afternoon of 10 May 2014. Showers and thunderstorms produced a precipitation maximum in the Piedmont of the Carolinas corresponding to the categorical PoPs generated by the camPoP tool. The CONS MOS[3] PoP (Fig. 9) showed much higher PoPs in the mountains of the western Carolinas and much lower PoPs over the Piedmont. In this situation, blending the PoPs generated by the camPoP tool (Fig. 10) with the CONS MOS PoPs would have adjusted the PoP field to more accurately reflect the radar estimated rainfall distribution across the forecast area.

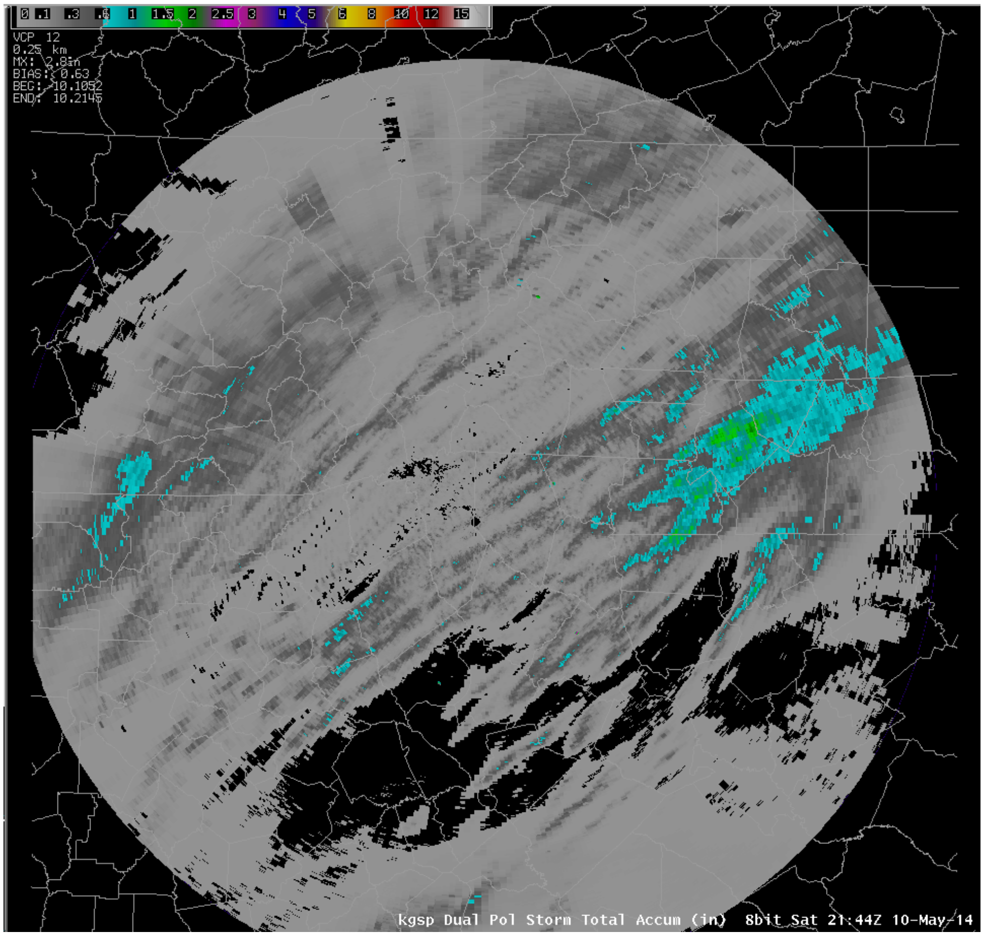


**Fig. 8. Dual Pol Storm Total Precipitation Accumulation starting at 1052 UTC 10 May 2014 and ending at 2145 UTC 10 May 2014**

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[3] CONS MOS is a consensus of the GFS, GEFS, NAM, and ECMWF MOS forecasts.

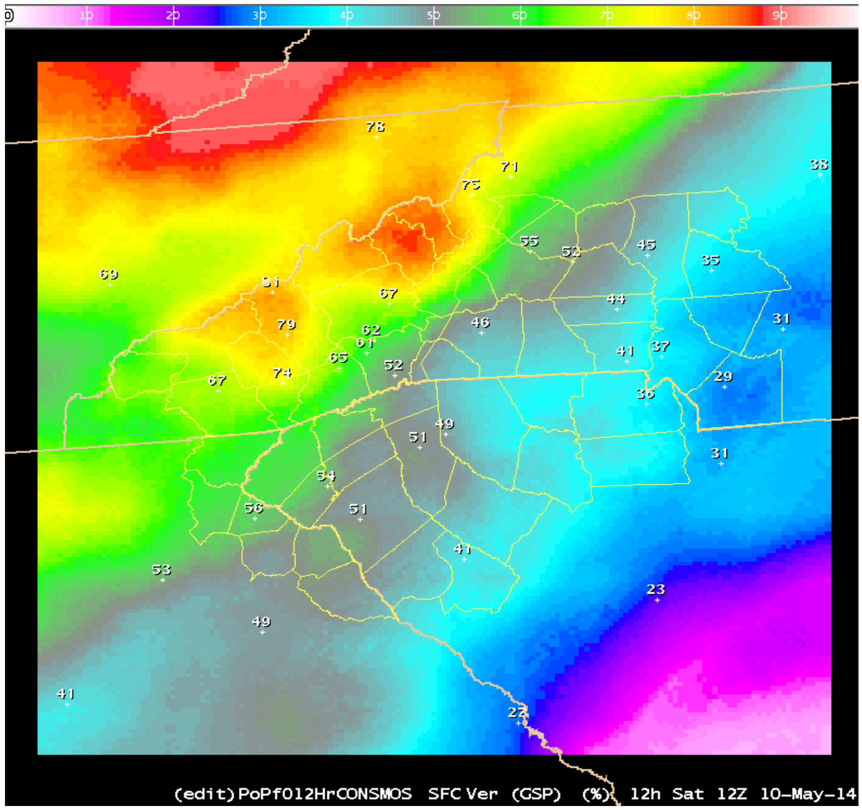


**Fig. 9. 1200 UTC CONSMOS PoP grid valid from 1200 UTC 10 May 2014 to 0000 UTC 11 May 2014.**

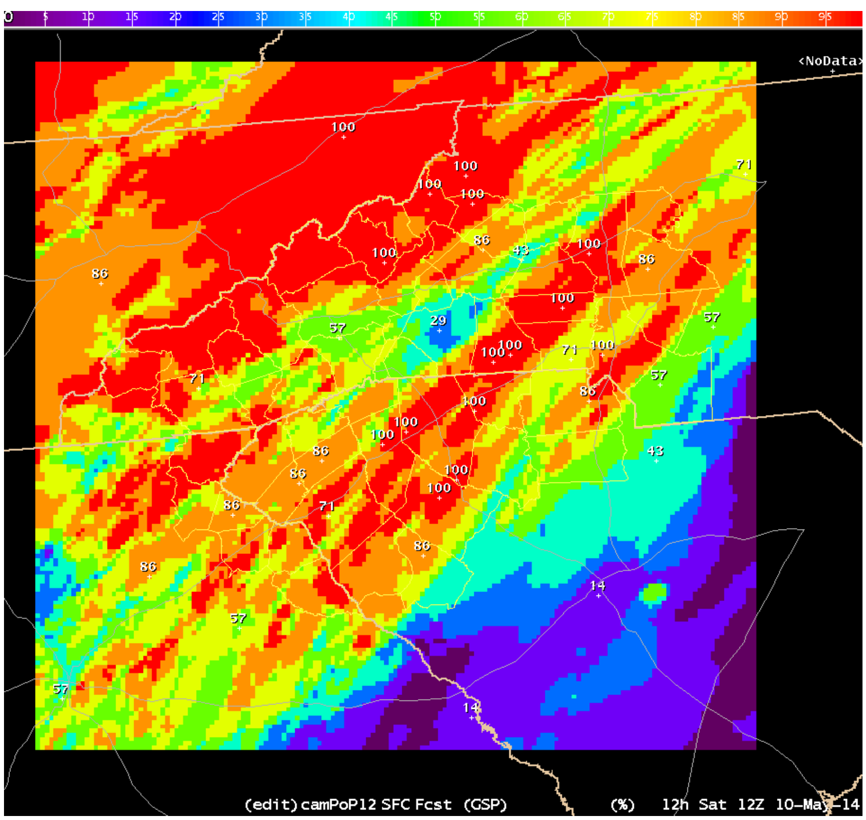


**Fig. 10. 1200 UTC camPoP12 grid valid from 1200 UTC 10 May 2014 to 0000 UTC 11 May 2014.**

***b) Cool season examples.***

The original motivation behind the development of camPoP was to produce a near-term guidance source during warm-season convection. However, it has been observed that camPoP has also performed well during non-convective events. For example, Fig. 11 shows the observed dual-pol radar storm total precipitation on 5 January 2014. This stratiform precipitation resulted from a region of moist, isentropic lift affecting the area. The camPoP grids (Fig. 12) captured well the relatively high coverage of precipitation across the foothills and Piedmont of the western Carolinas.

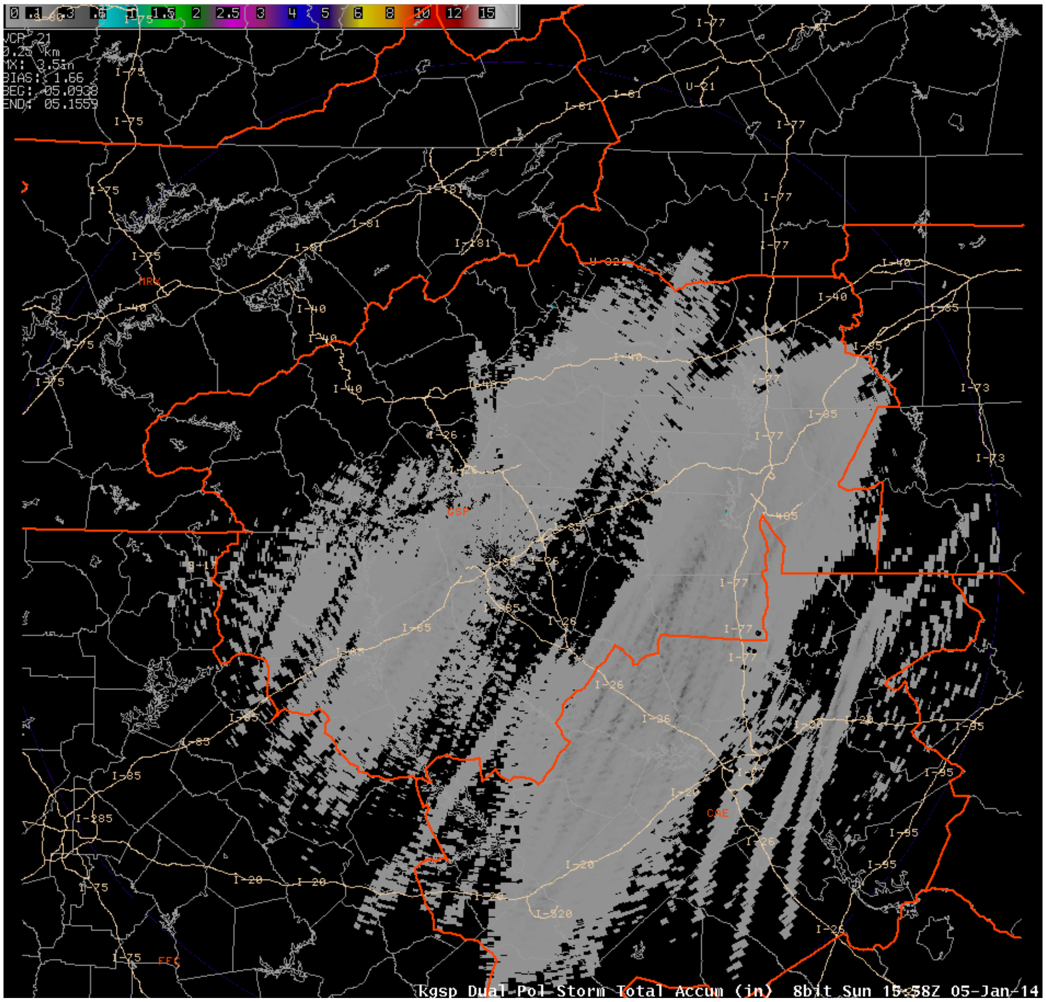


**Fig. 11. Dual Pol Storm Total Precipitation Accumulation starting at 0938 UTC 5 January 2014 and ending at 15:58 UTC 5 January 2014.**

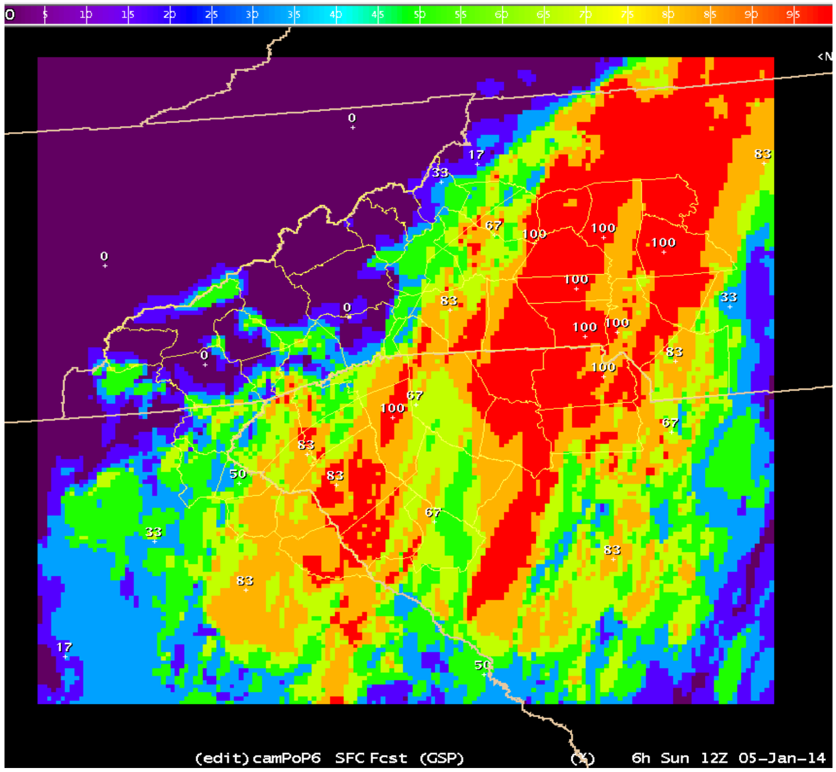


**Fig. 12. 1200 UTC camPoP6 grid valid from 1200 UTC 5 January 2014 to 1800 UTC 5 January 2014.**

The camPoP also performed well during the northwest upslope flow induced snow event. Fig.13 shows the observed dual-pol radar precipitation totals from the evening and overnight hours of 17 December 2013. The camPoP grid (Fig. 14) captured the high coverage of precipitation across the Blue Ridge area of the southern Appalachians.

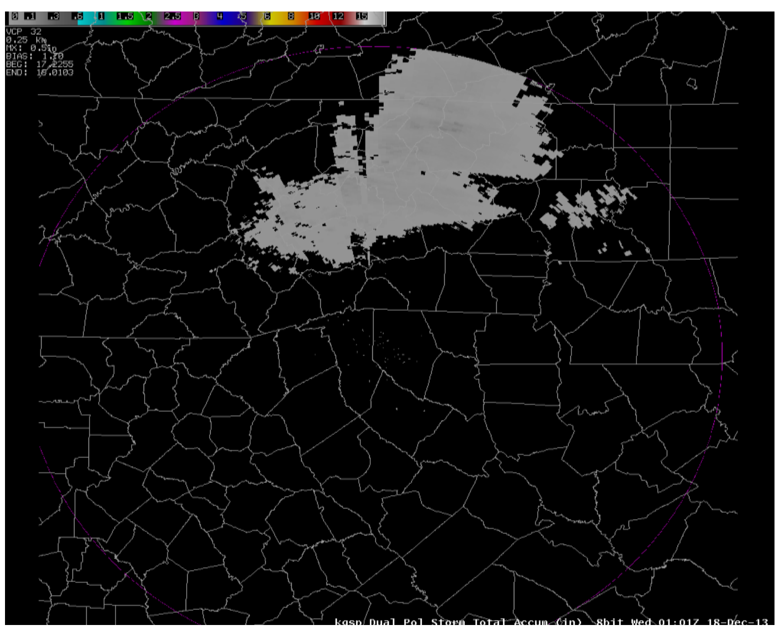

**Fig. 13. Dual Pol Storm Total Precipitation Accumulation starting at 2255 UTC 17 December 2013 and ending at 0101 UTC 18 December 2013.**

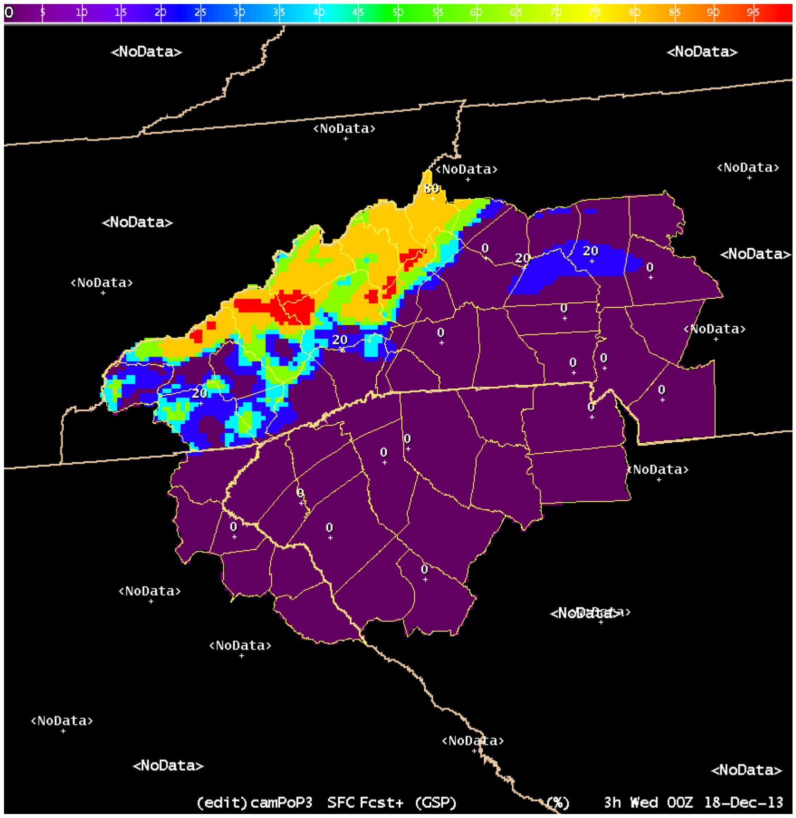


**Fig. 14. 0000UTC camPoP3 grid valid from 0000 UTC 18 December 2013 to 0300 UTC 18 December 2013.**

## 5. Conclusion

Examination of a limited number of both warm and cool season events suggests that camPoP guidance can add value to PoP forecasts year-round. However, more rigorous verification will be needed to assess the true utility of camPoP. Since the PoP grids generated by the camPoP process are not currently available to BOIVerify for grid-based verification, a point-verification study will be performed in the near future to better assess the utility of the camPoP guidance.

The camPoP , camQPF and PoPfmCAMPoP tools can be implemented easily at any WFO using their own custom set of convection-allowing models. These methods are available for both AWIPS1 and AWIP2 platforms on the Software Collaboration Portal (SCP) at:

https://collaborate.nws.noaa.gov/trac/nwsscp/wiki/Gfe/Procedures/CamPopQpf

REFERENCE

Jirak, I.L., S. J. Weiss, and C. J. Melick, 2012: The SPC Storm-scale Ensemble of Opportunity: Overview and Results from the 2012 Hazardous Weather Testbed Spring Forecasting Experiment. Preprints, *26th Conf. Severe Local Storms*, Nashville, TN, 5 pp.